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Progress Report

STUDY AND DESIGN OF MULTIPLE OR
STACKED DETECTORS AND A
SINGLE FIXED DETECTOR

Prepared for

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INTRODUCTION

Most of the planned program as outlined in the previous progress report has been realized. The performance of the x-ray vidicon detector has been ~~further~~ improved and the operating principle of the flat-plate geiger counter has been established. A complete electronic readout system has been fabricated and evaluated for operation with a multi-chamber geiger counter. A Seeman-Bohling focussing camera has been built and evaluated and shows the expected increase in intensity over the Bragg diffractometer.

REPORT OF PROGRESS

X-RAY OPTICS

Previous studies mentioned in the last report have pointed out the the advantages of a Seeman-Bohling camera for this application. In particular, this camera has the advantage that no scanning mechanism is required for presentation of the complete diffraction pattern. Furthermore, improvements in intensity can be realized.

To capitalize on these advantages, it was decided to construct a camera arrangement as shown schematically in Figure 1 with Figure 2 showing a photograph of the actual mechanical arrangement. The camera was built around an available standard x-ray tube for the sake of convenience, although further substantial improvements are to be expected by going to a smaller size x-ray tube. However, the particular dimensions chosen result in a radius of the Rowland circle which is very close to the radius of the focussing circle for the Surveyor Bragg-type diffractometer at the 101 diffracted line of quartz, thereby allowing a direct comparison of all performance characteristics of the two systems. The specific design parameters of the prototype camera are a radius of the Rowland circle of 17.3 centimeters, a curved sample holder 1.5 inches long, an x-ray tube take-off angle of 5.5°, and a tube-to-sample distance of 6.5 centimeters. A receiving slit of 0.006 inch was used with the scintillation counter and
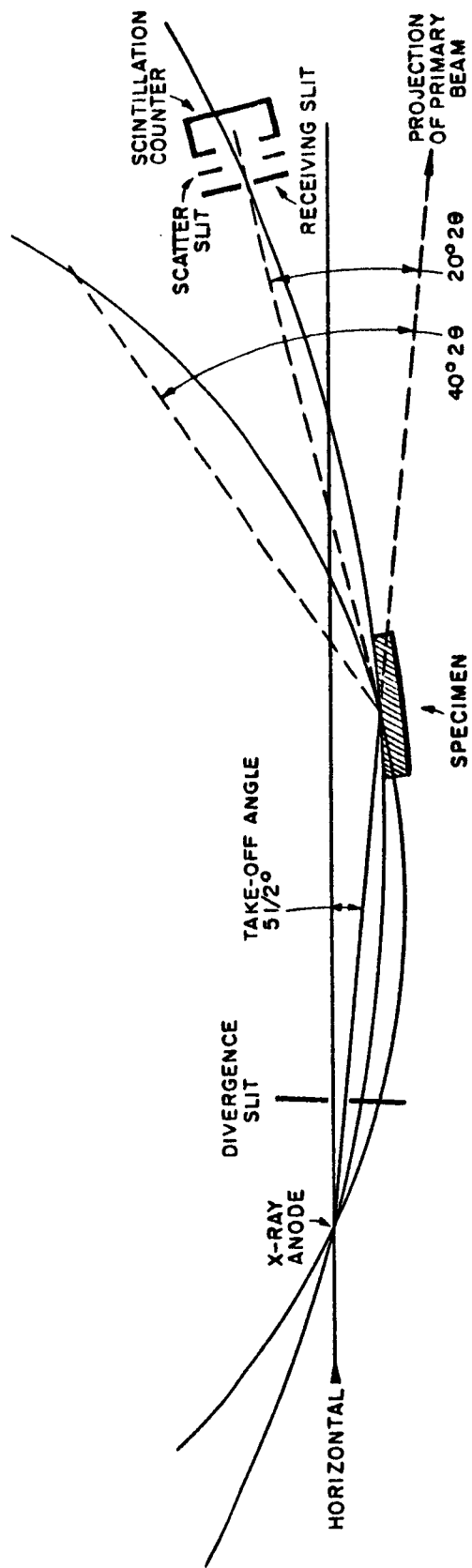
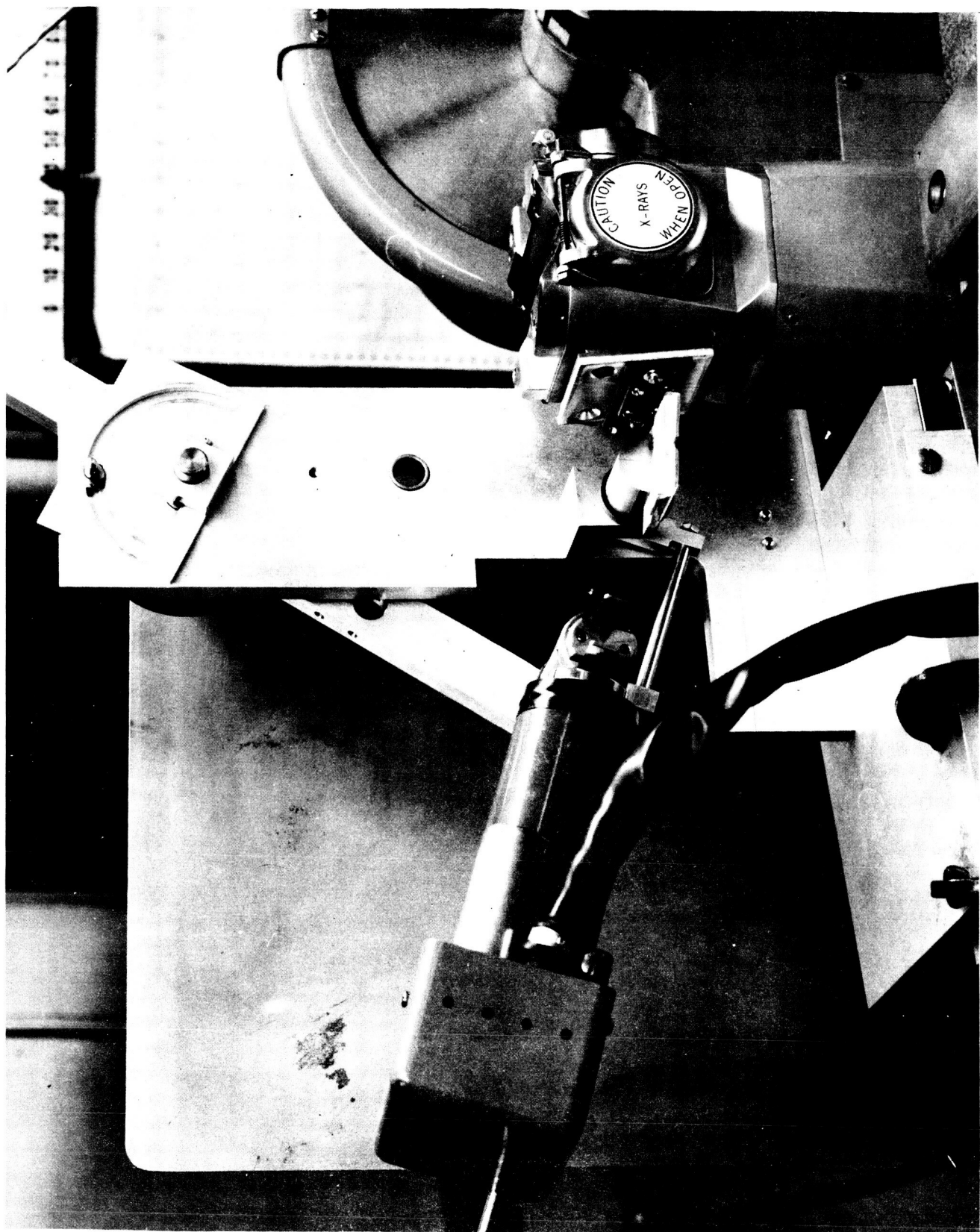Figure 1. Focussing Geometry Schematic Diagram.

Figure 2. Focussing Camera with Scintillation Counter.

appropriate divergence, scatter, and solar slits were incorporated. Figure 3 shows a typical run on a sample of alpha quartz with the first six reflections. Some of the operational data for this run is summarized in Table I.

The main results obtained from this experiment are the peak intensities for the diffracted lines, the resolution of the lines, and the peak-to-background ratio. A peak intensity for the 101 reflection is on the order of 9,000 counts per second or about twice the value obtained on the Surveyor Bragg-type diffractometer under equivalent conditions. The resolution is 0.3° which is somewhat worse than the Surveyor instrument, but it is possible that more precise alignment will result in improved resolution.

The relative peak intensity for the first six lines is summarized in Table II which compares the Seeman-Bohling camera, the conventional Bragg diffractometer, and the ASTM reference file. As expected, some of the reflections corresponding to larger Bragg angles are relatively weaker in the Seeman-Bohling camera. The most encouraging result, however, was the relatively high signal-to-background ratio obtained. The value of this ratio was about fifty, which is not worse than the Bragg-type diffractometer and fairly constant over a wide angular range. Theoretical considerations indicate that intensity and signal-to-background ratio should improve with a smaller radius of the Rowland circle and some of the planned future effort will be to investigate the influence of the radius of the Rowland circle on the performance characteristics.
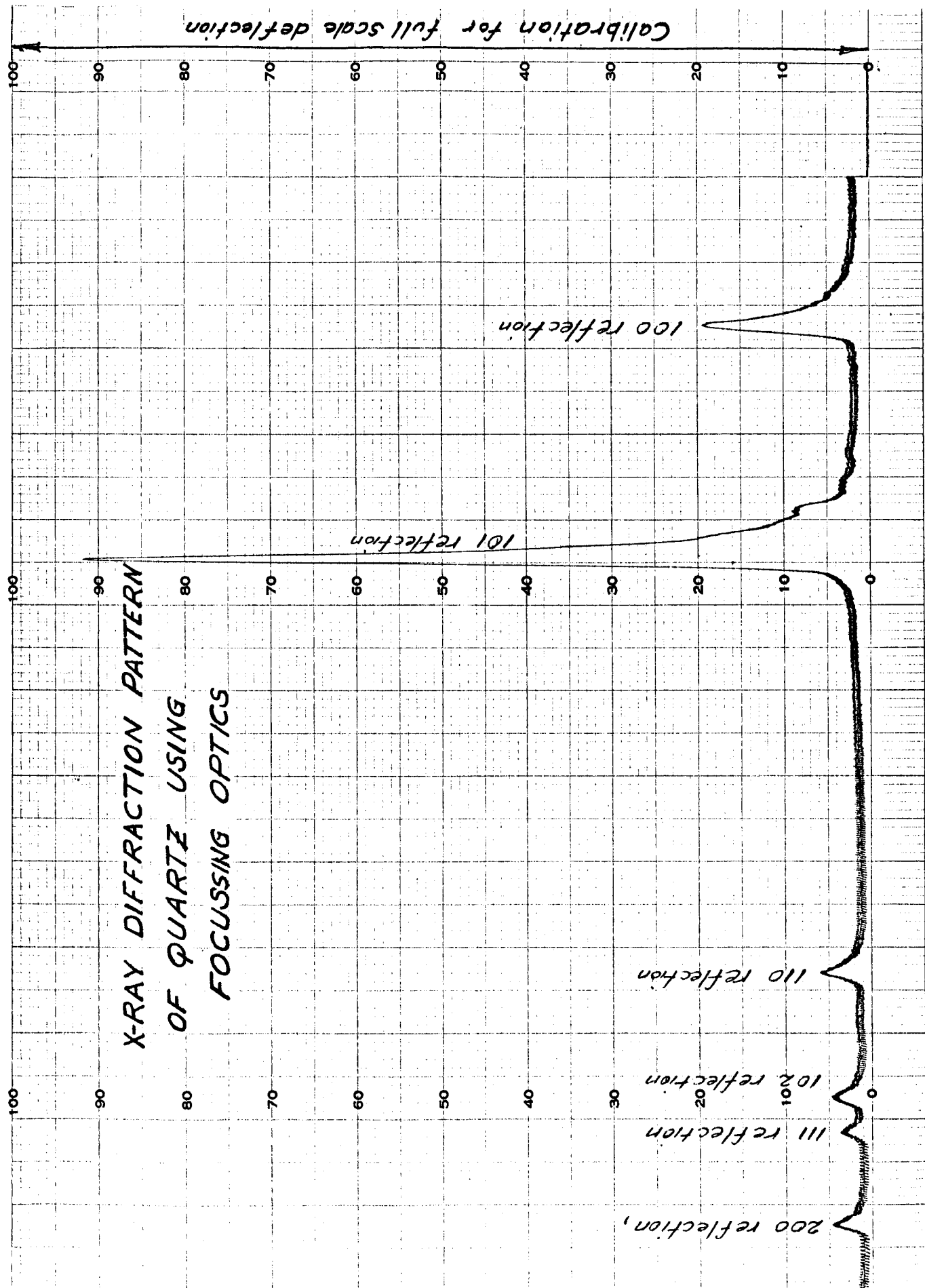
Figure 3.   First Six Reflections of Alpha Quartz.

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TABLE I

Operational Data for Typical
Run on a Sample of Alpha Quartz
(See Figure 3)

X-Ray Optics	Focussing Asymmetric Camera
Material	Alpha Quartz
Radiation	Copper K-alpha at 25 watts
Scale Factor	32
Multiplier	0.8
Time Constant	2
Pulse Height Discriminator	Scale Factor - 8 Base Voltage - 6.3 Window Voltage - 18 Gain - 20
Scintillation Counter	1000 V
Divergence Slit	3 mm
Receiving Slit	0.006"
Scatter Slit	4°
Full Scale Deflection	10,240 c/s

TABLE II

Comparison of Relative Peak Intensity
for the First Six Alpha Quartz Reflections

Reflection Plane (hkl)	Modified Asymmetric Focussing Camera	Conventional Goniometric Diffraction Pattern	ASTM Reference #5-0490
		Relative Units	
100	19	23	35
101	100	100	100
110	5	8	12
102	3	6	12
111	2	4	6
200	4	4	9

X-RAY VIDICON SYSTEM

This task of the program is concerned with the feasibility of using an x-ray sensitive vidicon tube as a detector for the x-ray diffraction apparatus.

Preliminary work was done with a borrowed closed-circuit TV camera and monitor utilizing an x-ray sensitive vidicon tube in the camera. The reflections from the 200 plane of a single crystal of lithium fluoride were observed on the TV monitor screen with an x-ray source equivalent to one having a 25-watt power input. Resolution of the diffracted beam was such that it was easy to discern $K\alpha_1$ and $K\alpha_2$.

It was reasoned that the sensitivity of the camera could be improved by a higher gain amplifier with decreased bandwidth to decrease amplifier noise. Integration of the signal would also be helpful to reduce the noise output. Slower sweeps would be necessary with the narrow band amplifier. The slower sweep or a wait period would also be desirable to allow the vidicon screen to build up a charge from low count radiation.

A camera was purchased and modified to provide sweeps with respect to an x-ray spectral line as shown in the sketch below.

Frame Sweep Time: 0.2 to 8 Seconds

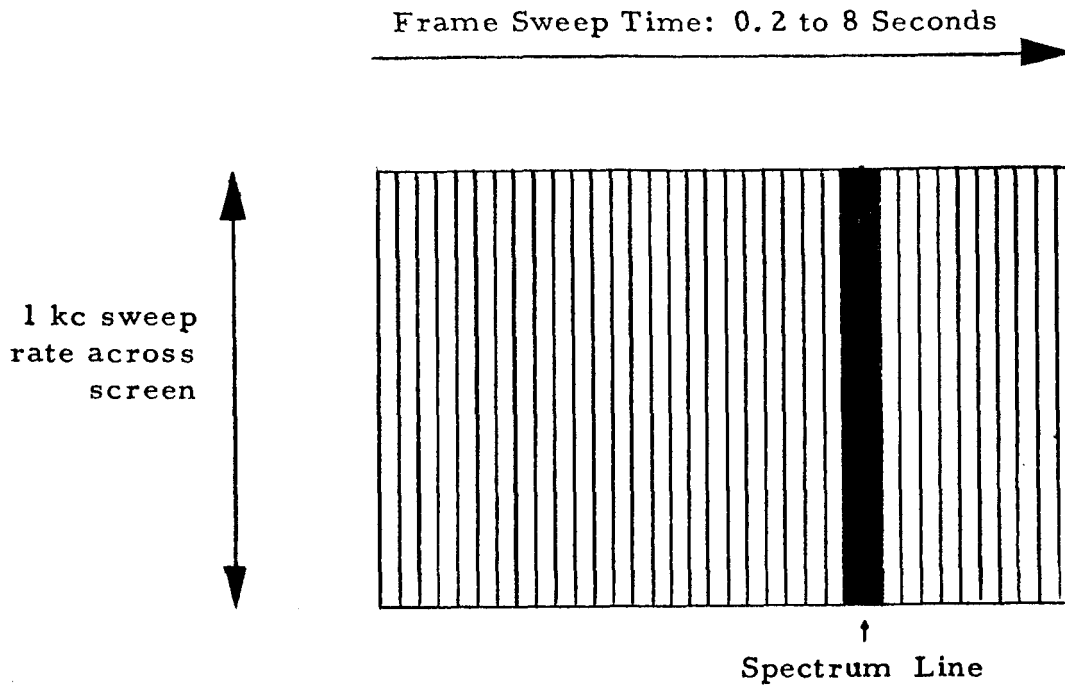**1 kc sweep rate across screen**

Spectrum Line

Figure 4.   Sweep Signals on Vidicon Screen.

Figure 5 is a photograph of the vidicon assembly mounted in position for acceptance of a collimated x-ray beam.

A one-kilocycle sweep across the screen was selected as slow enough to keep the amplifier bandwidth requirements low but high enough to eliminate the need for bulky coupling capacitors. With a frame sweep time of one second, the frame would contain 500 lines. An adjustable delay was provided between sweeps to allow the screen time to charge. This delay could be set from 0.5 to 30 seconds.

The output of this system was displayed on a standard oscilloscope with the scope sweep triggered to be concurrent with the camera frame
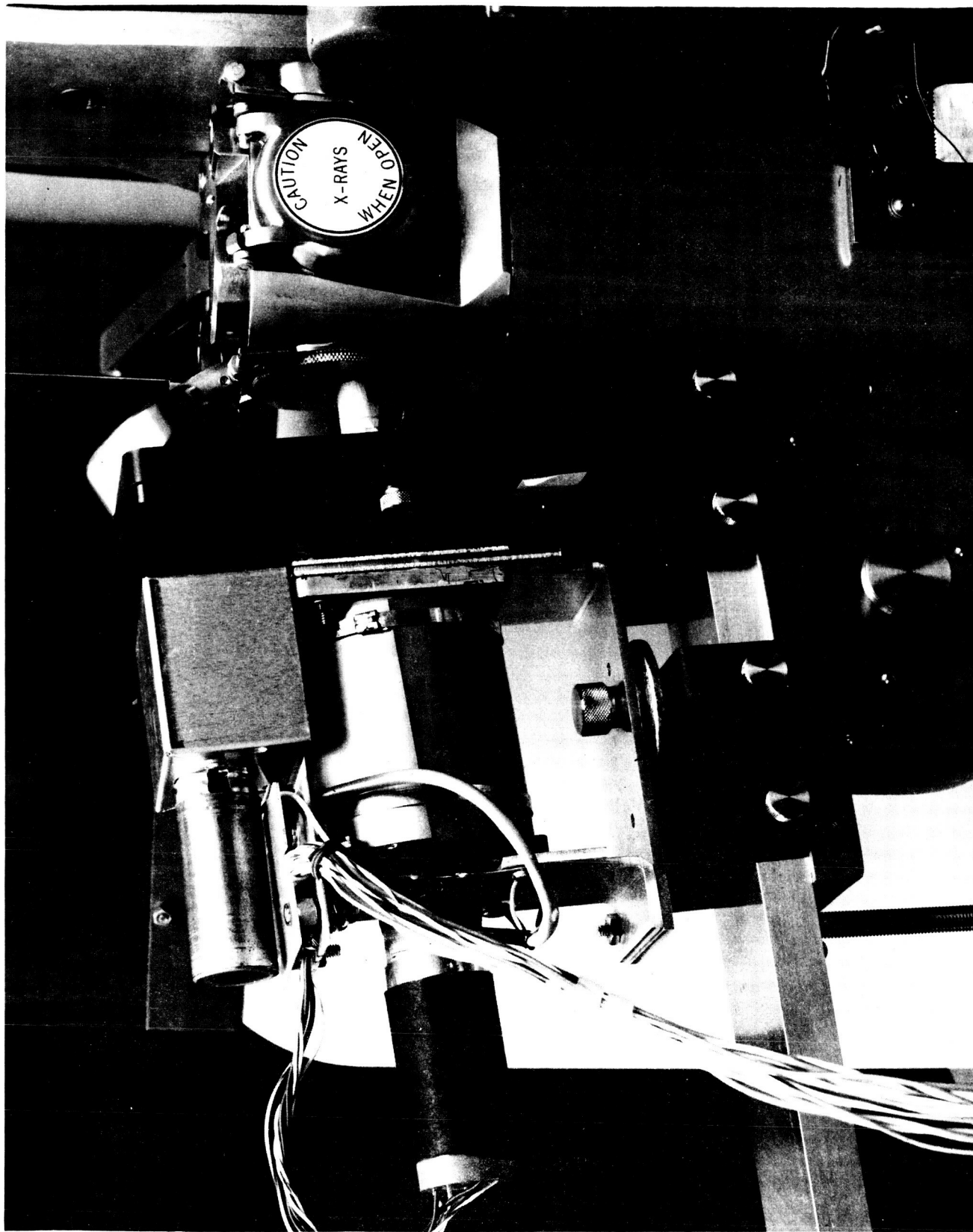
Figure 5. Vidicon Camera Assembly with Direct X-Ray Beam.

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sweep. The output of the amplifier representing a spectral line was integrated and applied to the vertical amplifier of the scope giving a presentation as shown in the photograph below.
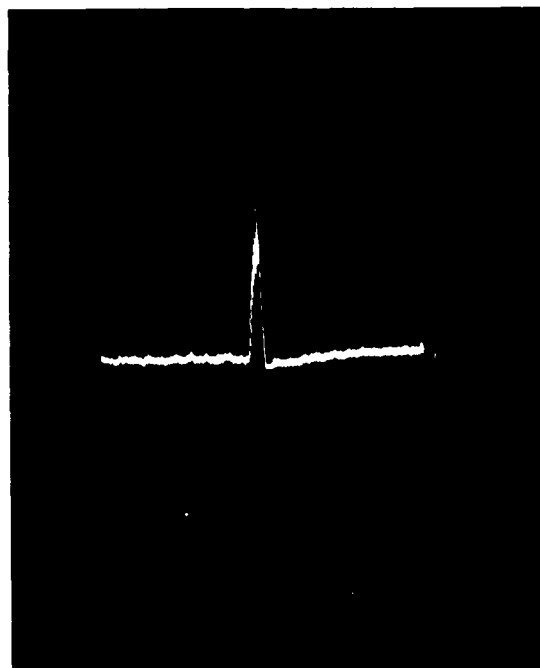

Figure 6. Oscilloscope Presentation.

The TV camera was set up in a calibrated direct beam from the x-ray generator with a 0.003 inch wide slit between the source and the vidicon screen. Nickel foils with known attenuation factors were inserted between the slit and the vidicon screen to vary the count rate.

The best sensitivity achieved to date has been a count rate of 59,500 counts/sec/mm^2 with a signal-to-noise ratio of two to one. The screen was allowed to charge for 30 seconds.

At present, noise generated by the vidicon tube appears to be the limiting factor on sensitivity. Increasing the charge time for the vidicon screen also increases the noise output from the screen, off-setting the improvement in signal output.

As it now stands, the system needs a considerable improvement in sensitivity. Some increase may come from longer storage time when the best storage conditions (electrode voltages) are determined for the vidicon during these long storage times. Some improvement should come from a special vidicon which is on order. This tube will have no glass between the beryllium faceplate and the screen. The tube will also have two different thicknesses of screen material on each half of the scene to make it possible to evaluate sensitivity improvement by the use of a thinner screen.

During the next reporting period the major effort on this task will be devoted to improving the system sensitivity and to the evaluation of the special vidicon now on order.

DATA HANDLING AND PRESENTATION

As an integral and essential part of this program, a data handling and presentation system was designed and a feasibility model constructed. The objective of this task was verification that the information out of the x-ray detectors could be processed in a manner consistent with the constraints of the over-all mission.

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The system was designed to be applicable to any detector producing output counts or pulses, but an array of amplifiers was constructed specifically to match the outputs of the multiple geiger tube. A block diagram of the system logic is shown in Figure 7. Channels 3 through 9 are omitted from the drawing, but all ten channels have been constructed.

Although preliminary check-out has been carried out, completion of the system and final check-out has been postponed, of necessity, until the arrival of the multiple geiger tube. All data reduction circuits and the controls for readout are housed in the desk-top 19-inch rack, shown in Figure 8, along with supporting equipment.

The data handling system consists primarily of a system clock, scanning circuits and ten information channels plus a sync signal. Incoming information from the ten individual channels of the geiger tube are fed into N/4 counters to provide temporary storage until the output of the channel is scanned and then reset to zero. Scanning of the output of the channels is controlled by the clock rate of 30 kc. This rate allows for simultaneous inputs on each of the ten channels varying independently from zero to more than 10,000 counts per second. The present data handling system could handle an incoming data rate of up to 36,000 counts per second per channel simply by increasing the clock frequency to its maximum rate of 100 kc. Commercial logic cards of the type shown in Figure 9 were used throughout the system with the exception of the input buffer amplifiers. Special input
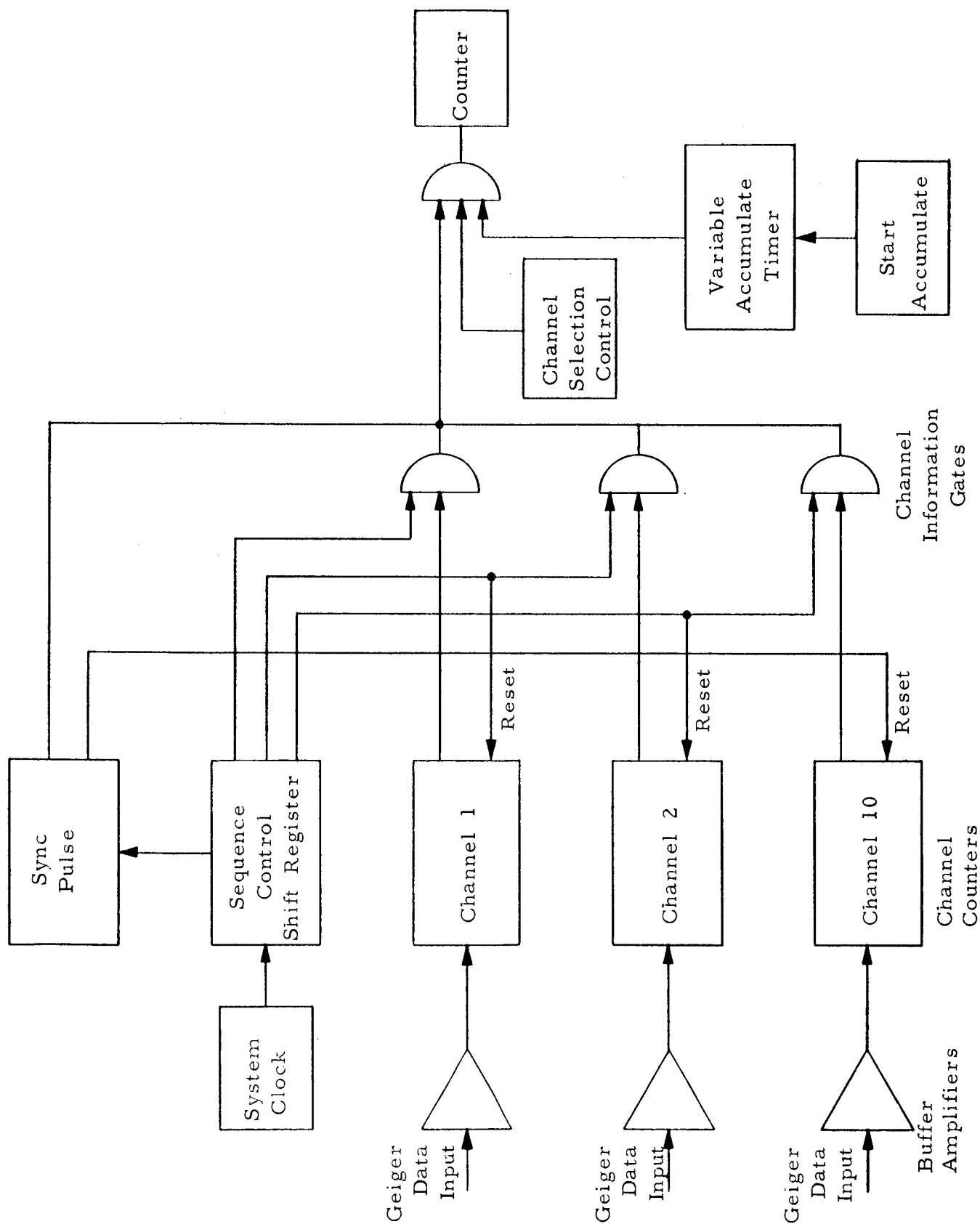
Figure 7. Abbreviated Block Diagram of Data Accumulation and Display System.
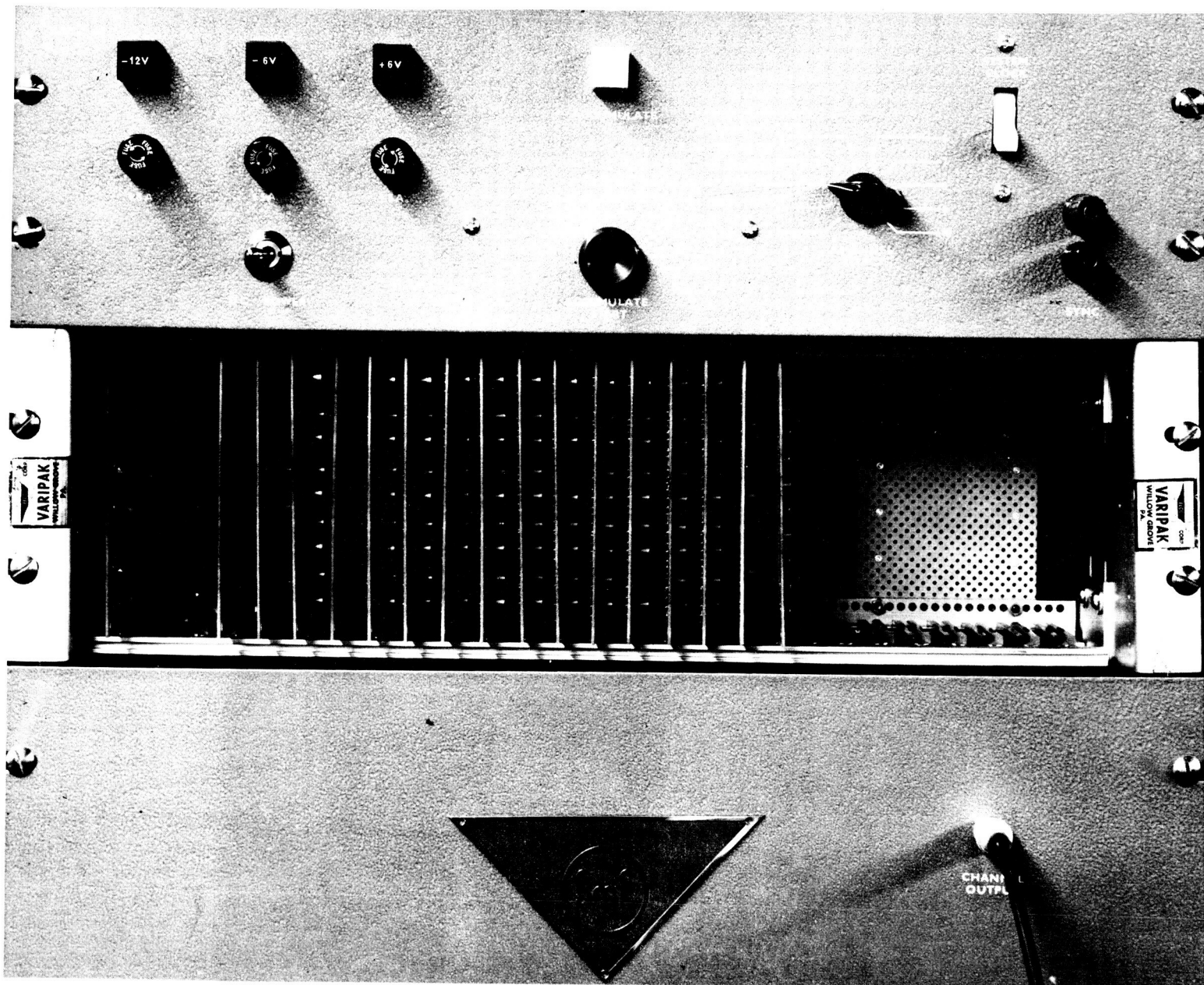
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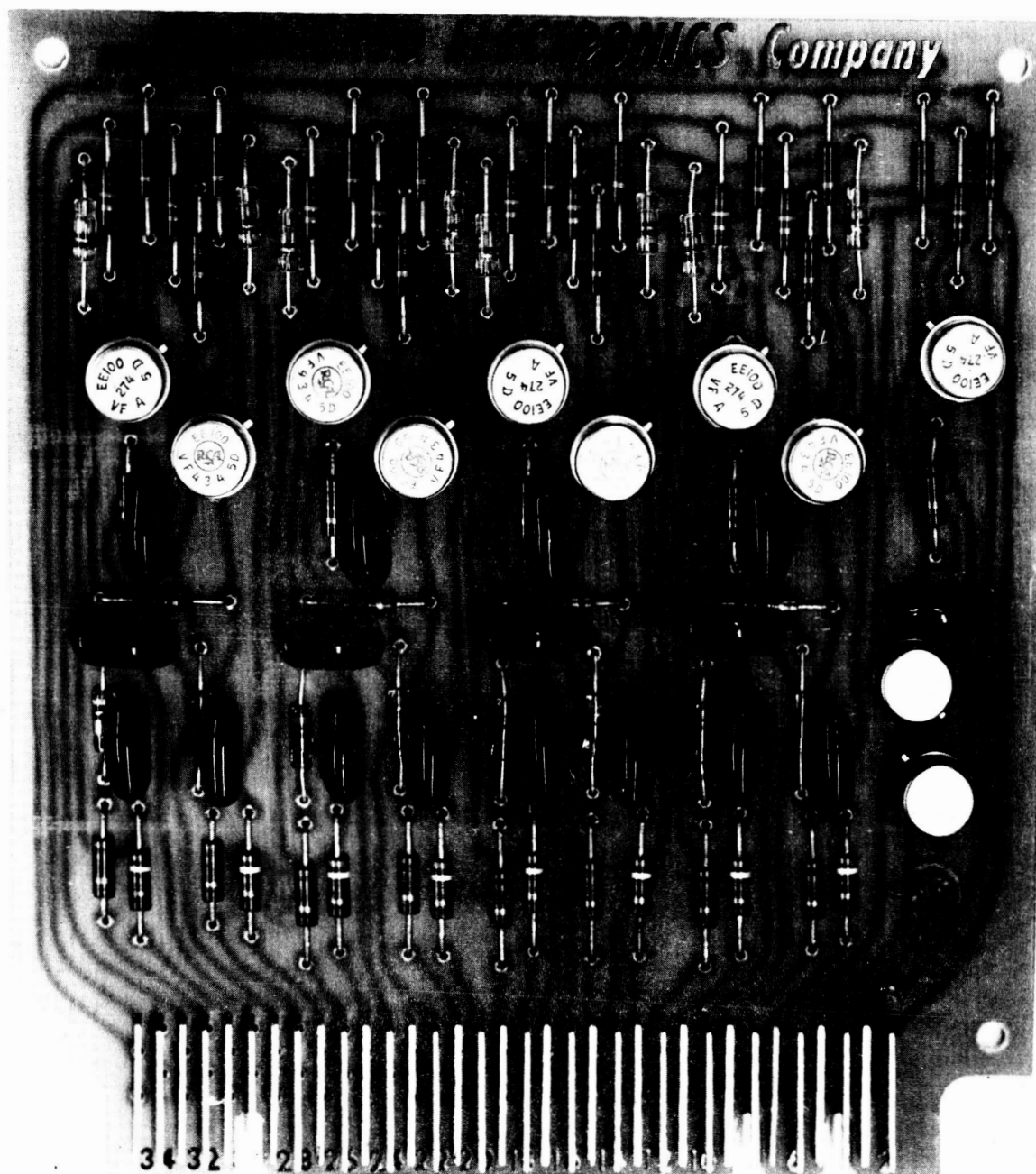Figure 8.   Data Reduction Circuits and Readout Controls.

Figure 9.   Commercial Logic Card Used in Data Reduction Circuits.

amplifiers were designed to make the transition between the geiger tube outputs and the input requirements of the logic circuits. As the outputs of the channels are scanned, the information is gated onto a single line in serial fashion for transmission to the readout point. In a flight instrument the readout point would be the spacecraft telemetry system.

Selective readout was chosen rather than simultaneous readout primarily to reduce the cost of the feasibility model. After choosing the channel with the selector switch on the master control panel, the "Accumulate" button is depressed momentarily to activate the readout circuits for a predetermined period of time. The count occurring during this time is then accumulated and displayed on a Hewlett-Packard counter. Pressing the "Accumulate" button activates an audio oscillator and a C.M.C. preset counter which are used to control the length of time that data is presented to the counter. Time intervals for accumulation may be varied from one second to 100 seconds with an accuracy of greater than 1 percent. Varying the time for data accumulation is controlled by the oscillator frequency and/or the preset count.

The techniques used in the feasibility model to put all the information on one line and recover individual channel information are directly applicable to a 500-channel system. In the larger system the clock rate would have to be increased to approximately 1.25 megacycles or the capacity of the channel counters would have to be increased to gain sufficient temporary

storage. An oscillator and shift register duplicating the ones in the transmitting unit would be needed at the receiving end to recover the individual channel information. By detecting the sync signal in the information stream and using it to synchronize the oscillator and the shift register, recovery of the information becomes exactly the reverse of the process used to put it into serial form. The ten-channel feasibility system utilizes the same oscillator and shift register for reducing the data to serial form and recovering it.

As a result of this effort it is clear that the detector outputs can be handled in a manner economical in terms of size, weight, cost, and telemetry capacity. The performance with a particular detector, such as the multiple geiger tube, remains to be demonstrated but is not expected to present any unusual problems.

During the next reporting period, the data system will be evaluated in operation with the multiple geiger tube, pending delivery of the latter.

SUMMARY

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In the detector area further improvements were made in raising the sensitivity of the x-ray vidicon. Final evaluation of this method will be accomplished when a tube specially built for soft x-rays is delivered. The flat parallel plate geiger counter has been proven to be operational although some difficulties are being encountered during fabrication with the seals on the windows. For this reason it will be necessary to employ ceramic seals in the construction of these counters. In the meantime work will proceed with a simplified 2-or-3 chamber counter. Complete electronic readout circuits simulating data transmission of a multiple chamber geiger counter over a single telemetry link has been constructed and evaluated.

In the area of x-ray optics a complete simulated Seeman-Bohling camera has been constructed and has undergone preliminary evaluation and shows, in comparison with the Surveyor-type x-ray diffractometer, an increase in intensity by a factor of two with approximately the same resolution, signal-to-background ratio, and x-ray tube power.

The following program is planned for the next two-month period:

1. Complete evaluation of x-ray vidicon.
2. Complete evaluation of multi-chamber geiger counter.
3. Evaluate Seeman-Bohling camera with the above-mentioned two counters.